HAND-BOOK

TO ACCOMPANY

THE SYNOPTIC TABLE

OF

MEASURES AND WEIGHTS

Phillips Library,
OF THE
H.C.O.

METRIC SYSTEM

CONSTRUCTED BY

CHARLES H. DOWLING, C.E.

BY

JAMES YATES, M.A.

&c. &c.

EDINBURGH

W. & A. K. JOHNSTON, 4 ST ANDREW SQUARE

GEOGRAPHERS AND ENGRAVERS TO THE QUEEN

London: E. STANFORD, GROOMBRIDGE & SON
AND W. ALLAN & CO.

Dublin: M'GLASHAN & GILL

MDCCCLXIV.

Advertisement.

Mr Dowling's "*Synoptic Table*," hereinafter described, mounted on cloth with rollers, so as to be conveniently displayed in School-rooms, Lecture-rooms, and similar Institutions, is 1½ metres, or 4 ft. 11 in. wide, and 1 metre 23 cents, or about 4 ft. high.

Price—With Hand-book, Coloured, on Cloth and Rollers, 15s.

"   "   "   "   Varnished, 17s.

"   "   "   4to Portfolio,   15s.
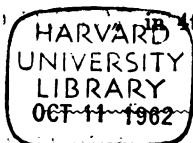
BY THE SAME AUTHOR,

A Series of Tables for comparing the Metric Measures and Weights with those of the British Standard.

Price 10s. 6d.

LOCKWOOD & CO.

Stationers' Hall Court, London.

W. & A. K. JOHNSTON, Edinburgh.

DESCRIPTION

OF A

SYNOPTIC TABLE

OF THE

MEASURES AND WEIGHTS

OF THE

METRIC SYSTEM.

THE Metric System of Measures and Weights was intended to be international and universal. All nations were invited to join in its formation. Many having responded, it is now established by law in the following countries :

EUROPE.

France, since January 1, 1840.
Belgium, since June 18, 1836.
Holland, since January 1, 1821.
Greece, since 1836.
Spain, since 1859.
Portugal, since January 1, 1863.
Italy, except the Popedom, commencing at various periods in different parts.
Switzerland, with modifications.
Germany, with various modifications.
Denmark, partially.

AFRICA.

Algeria.

Colonies of Portugal.

EAST AND WEST INDIES.

Colonies of Spain, France, and Portugal.

AMERICA.

Mexico.

Chili.

Peru.

New Granada.

Ecuador, to commence in 1866.

Bolivia.

Venezuela.

French and Dutch Guiana.

The same system, though not enforced by law, is much used for scientific, statistical, and engineering purposes in Great Britain, Sweden, Norway, and Russia.

The Commissioners, who were appointed to construct this system, thought that they were most likely to escape all suspicion of partiality, and to obtain the co-operation of the world at large, by avoiding the use of any measures or weights, which were already in existence; and that the earth itself presented the most suitable basis for a method which was intended to be used by all its inhabitants, and to measure and weigh all natural and artificial products upon its surface. Having proceeded thus far, they found that their choice of a fundamental linear measure lay between the pendulum vibrating seconds at a certain latitude, and the length of a certain portion of the earth. Also, after they had given up the pendulum, they found it necessary to decide

whether it would be better to take a portion of the earth's axis, a portion of its circumference calculated at the equator, or a portion of one of its meridians. They resolved upon taking the ten-millionth part of the quadrant of a meridian, measured by calculation from the north pole to the equator. This quadrant is shewn in a conspicuous part of the Synoptic Table. It is placed so that it may appear to be the commencement of the system, and its length is stated to be ONE THOUSAND MYRIAMETRES. The term *Myriametre* will be easily understood to mean a *Myriad of Metres*, and it must be borne in mind that *Metre*, meaning *measure*, is the name of that fundamental unit of length which is the basis of the system. From this circumstance it is called THE METRIC SYSTEM.

The metre is placed in a central part of the table, above the other measures. It is drawn nearly of the real length, and three centimetres broad. It is marked with its decimal divisions, being divided into 10 decimetres, each of which is divided into 10 centimetres. The decimetre at one end is also subdivided into 100 millimetres. Thus it is shewn, that a metre is equal to 10 decimetres, 100 centimetres, and 1000 millimetres.

The equivalent of the metre in English feet and inches is stated to be 3 feet, 3 inches, and ⅜ths of an inch. In the draper's shops of London this quantity is expressed by calling a metre *three threes*. More accurately the metre is determined by the law of France to be the length of the bar of platinum, which was deposited by the authority of the government in the French archives on the 22d of June 1799, and which has been kept there ever since. An accurate copy of this original standard, also of platinum, belongs to the Royal Society, and was used by the Royal Commissioners for the purpose of obtaining an accurate computation of the ·

length of the metre in English inches.   In July 1820 these
Commissioners gave in their report to the House of Commons.
They stated the metre to be 39·37079 inches, and this state-
ment has been generally accepted ever since.

On account of the importance of the *Decimetre*, or *Hand*,
and of the *Double Decimetre*, or *Link*, they are drawn of the
real size to the right of the metre.   We observe here the
first example of a rule which pervades the whole Metric
System—viz., that each of the main decimal divisions, both
in measures and in weights, has its half and its double.   In
subordination to this rule, we may assume the *Half Metre*
and the *Double Metre*, and we may call them the *Cubit* and the
Fathom of the Metric System, since these terms have always
been used with considerable latitude, but never so as to
exclude the application here proposed.

The dimensions of the table further admit a good repre-
sentation of the *Double Decametre*, or *Chain*.   This is the
most important *Land Measure*.   It is shewn in two forms,
both of English manufacture—viz., the *Measuring Tape*,
including longitudinal wires to prevent dilatation and con-
traction through moisture, and the *Steel Chain* of 100 links.
The chain of the Metric System here drawn is only about one-
two-hundredth part less than the English chain,[1] the incon-
venience of which is strongly insisted on by the Commis-
sioners, who reported in 1841 on the restoration of the
Standards of Weights and Measures.   *See* Report, § VII.   The
" anomaly " to which they object will be entirely removed,
if the Metric System be adopted.

Immediately under the figure of the earth we observe the
following table :—

---

[1] The English chain of 4 poles, or 22 yards, is 20·11644 metres.

ELEMENTS OF THE SYSTEM.

Length.	Surface.	Capacity.	Weight.	Notation.
			Ton.	1,000,000·
			Quintal.	100,000·
Myriametre.			Myriagram.	10,000·
Kilometre.		Kilolitre.	Kilogram.	1000·
Hectometre.	Hectare.	Hectolitre.	Hectogram.	100·
Decametre.	Decare.	Decalitre.	Decagram.	10·
METRE.	ARE.	LITRE.	GRAM.	1·
Decimetre.		Decilitre.	Decigram.	·1
Centimetre.	Centiare.	Centilitre.	Centigram.	·01
Millimetre.		Millilitre.	Milligram.	·001

The fundamental elements are the four UNITS—viz. :

> The METRE, for measures of Length.
> The ARE, for measures of Surface.
> The LITRE, for measures of Capacity.
> The GRAM, for Weights.

In many countries the Metric System provides another unit, called the STERE. It is the cube of a metre, and is useful where wood is burnt for fuel, as in France. But it is omitted in the present table, because the English habit of burning coal, which is sold by weight, makes it superfluous. The *Cubic Metre* suffices to describe and calculate large masses of earth, clay, gravel, and other solid substances.

The four units are multiplied and divided decimally, the four Greek multiples being denoted by *Myria, Kilo, Hecto, Deca*, and the divisions by three familiar Latin terms, *Deci, Centi, Milli*. These seven terms are prefixed to the four names denoting the units in such a manner that a little reflection shews the relation of any one measure or weight to all the rest. It is remarkable that the same method has been adopted to a small extent in Great Britain. By the Weights and Measures Act, 5 George IV. c. 74, the Gallon is the "Unit of Capacity," and its "Fourth Part" (*pars quarta*) is declared to be "a Quart." Thus far—viz., in using a Latin term to express a division of the unit, our legislators copied France without knowing it.

In the manner now explained, the metre gives origin to the following multiples :

> The Myriametre.
> The Half Myriametre, or League.
> The Kilometre, being the Mile, or principal itinerary measure of the Metric System.
> The Double Hectometre, or Furlong.
> The Hectometre.
> The Double Decametre, or Chain.
> The Decametre.
> The Half Decametre, or Pole.
> The Double Metre, or Fathom.

And in the descending scale to the following divisions :

> The Half Metre, or Cubit.
> The Double Decimetre, or Link.
> The Decimetre, or Hand.
> The Centimetre, or Size.
> The Double Millimetre, or Line.
> The Millimetre, or Mil.

The ARE is the unit of land and superficial measure. It is the square of a decametre. It consequently contains 100 square metres, so that a square metre may, according to the systematic nomenclature, be called a *Centiare*. On the other hand, 100 ares is a *Hectare*. This is commonly used in describing landed estates, or other large portions of the earth's surface. The *Decare* being, as the term implies, 10 ares, is a very little less than an English rood, and consequently a *Double Decare* is a very little short of an English statute half acre.

The next unit is the LITRE. It is capacity of a cubic decimetre, and is the fundamental measure for all fluids, and for solids, which are computed in moderately small

masses or quantities. The following decimal divisions
and multiples, with their doubles and halves, are in use :

DENOMINATIONS.

1000·	Kilolitre, or Tun.
500·	Half Kilolitre, Pipe, or Butt.
100·	Hectolitre, or Sack for Corn.
50·	Half Hectolitre.
20·	Double Decalitre.
10·	Decalitre, or Peck.
5·	Half Decalitre, or Gallon.
2·	Double Litre.
1·	LITRE.
·5	Half Litre, or Pint.
·2	Double Decilitre.
·1	Decilitre.
·05	Half Decilitre.
·02	Double Centilitre.
·01	Centilitre.
·005	Half Centilitre.

The smallest of these measures are necessary in chemistry
and pharmacy, the largest in the corn-trade, and in selling
and preserving wine. The intermediate measures are used
everywhere in the shops and markets for retail trade, as well
as in domestic economy. The kilolitre has the capacity of
a cubic metre. The decalitre and its half are important on
account of their near approach to the English peck and
gallon.

The fourth column in the small table now under con-
sideration shews the elements of the SYSTEM OF WEIGHTS.
The unit is the GRAM, being the weight of the quantity of
distilled water, which at the temperature of its greatest
density fills a cubic centimetre. Its divisions are the
decigram, centigram, and milligram ; its multiples, the

decagram, hectogram, kilogram, and myriagram. Of these the most important is the kilogram, called by abbreviation the kilo, being something more than the 2-lb. avoirdupois,[1] and consequently adapted to weigh articles in the shops, such as groceries. At a proportionate distance we come to the ton, a weight never made in one mass, but calculated in figures, and equal to 1000 kilograms. This is continually used in the ports and in estimating the cargoes of ships. It is almost identical with the English ton. Thus the weights arrange themselves in three sets, depending upon three cardinal weights—viz., the gram for chemistry, pharmacy, metallurgy jewellery, &c.; the kilo for the shops and markets; the ton for the ports and warehouses. The heaviest weight which a man can lift is that of 50 kilos, being something less than one hundredweight English, so that on this system we may, by the use of one complete set of weights with scales, or other machinery, weigh in regular decimal steps any quantity from 5 myriagrams to half a milligram *i.e.*, from 50,000 grams to ·0005 gram.

On account of the obvious utility of the nomenclature here exhibited in eleven simple terms, each of which has a distinct signification, it is desirable that all children should both write it down and learn it by heart. They may thus be made familiar with the relation of the several parts of the system to one another. They may be allowed freely to use the corresponding English terms, but they should remember that these terms are of a more loose and general import than those which are peculiar to the Metric System. In all exact calculations it will be better to use the latter series, especially since they have the same precise meaning all over the world. Nor is there any real difficulty in learning to pronounce and remember them. Many persons complain of this obligation

---

[1] Exactly 2 lb., 3 ounces, 4 drams.

as a deplorable hardship. Those who find it difficult to master the pronunciation of the ten foreign words (for the word *metre* being a common English noun, though used in a different sense, must not be reckoned with the other ten), and who prefer English monosyllables, may remove the objection by calling the double decimetre, the decimetre, and the centimetre by the equivalent terms *Link, Hand, and Size.* Also it may be convenient to call centimetres and millimetres, *Cents* and *Mils,* as is done in Germany ; and if even these brief words require too great an effort for the "indomitable energy of the Anglo-Saxon race," they may be omitted altogether in many cases. When an English workman tells the dimensions of a piece of furniture, instead of saying that his table is 3 *feet* 6 *inches* long, and 2 *feet* 9 *inches* broad, he says it is 3 *feet* 6 by 2 *feet* 9. In the same manner, a French carpenter describes his table as 3 *metres* 26 by 2 *metres* 19, meaning that it is 3 *metres* 26 *centimetres* long, and 2 *metres* 19 *centimetres* broad. By such simple expedients brevity is consulted almost without rule or instruction. But a foundation ought to be laid in the knowledge of the true metric nomenclature, the apprehension of which implies no real difficulty. Children learn words by hundreds, which are much longer and more difficult. They even seem to take pleasure in learning them. The Christian names which mothers give to their female children prove this. One such name, *Millecent,* has been used among us from the time of King Alfred to the present day. If then a little girl has had the misfortune to be christened *Millecent,* it will be seen that, as soon as she knows her own name, she has overcome a fifth part of the difficulties of the metric nomenclature, and yet it is probable that the names of her companions, both boys and girls, are much more formidable.

We now return to the large Synoptic Table.

Immediately under the measures of length, a figure presents itself which is intended to explain the origin, first, of all the MEASURES OF CAPACITY, and secondly, of all the WEIGHTS. This is the *Cubic Decimetre*, which is drawn in isometric projection. A decimetre being taken in the middle of the metre, perpendiculars are let fall from its two extremities ; a decimetre being cut off from both the perpendiculars, the space between them is a square decimetre. Each of its four sides might be divided into 10 centimetres, and the square decimetre forming the side of the cube might be divided by parallel lines into 100 square centimetres. This would give a good illustration of superficial, or square measure. It would be seen, that as the square decimetre contains 100 square centimetres, so the square metre contains 100 square decimetres.

It will be observed further, that two straight lines are drawn parallel to the 4 sides of the square decimetre, so as to represent a cube in isometric projection. This cube shews the "capacity of a cubic decimetre." It is the "origin of the litre," and the same space filled with pure water, at the temperature of its greatest density, gives the weight of the kilogram ; for, as the gram is the weight of the quantity of water which fills a cubic centimetre, and a cubic decimetre is equal to 1000 cubic centimetres, it follows that the water which fills the latter space will weigh 1000 grams, or 1 kilogram.

To the right hand of the cubic decimetre are two rectangular solids, representing the 10th and the 100th parts of that figure, and consequently shewing the capacity of the 10th and the 100th parts of the litre. Accordingly the decilitre and the centilitre are drawn immediately under them. Also, as the water contained in these two measures will weigh respectively 100 grams and 10 grams, the figures of the hectogram and decagram are placed beneath them lower down.

For the purposes of trade the litre is produced in two principal forms, both cylindrical. These are the taller forms in pewter, used for measuring fluids, in which the height, measured internally, is twice the diameter, and the forms in wood, used for grain and other solids, in which the height, measured internally, is equal to the diameter.

The Synoptic Table shews a row of 9 pewter vessels. The largest is the measure of 5 litres, or the half decalitre, nearly equal to the English gallon. The litre being placed in the middle, immediately under the figure of the cubic decimetre, from which it is derived, its multiples and divisions are arranged on each side thus :

<div align="center">Values, 5, 2, 1 ; ·5, ·2, ·1 ; ·05, ·02, ·01.</div>

The systematic names of these 9 measures are the following:

<div align="center">

Half Decalitre

Double Litre.

Litre.

Half Litre.

Double Decilitre.

Decilitre.

Demi-Decilitre, or Half Decilitre.

Double Centilitre.

Centilitre.

</div>

When the smaller of these vessels are wanted for measuring milk, oil, or other fluids, they have handles adapted to plunge them into the fluid, and their diameter is then equal to their depth.

The next row below the 9 liquid measures shews the DRY MEASURES. These are only 8 in number, because although they begin with the decalitre, the peck of the Metric System, the centilitre and its double are omitted as unnecessary. These 8 measures are of wood, and their inside diameter is equal to their height.

Next come the weights in two rows so placed as to shew their relation to the measures of capacity. The upper row exhibits 16 weights of brass, cylindrical, with a knob to lift them. The lower row shews 8 weights of iron, hexagonal, for ruder work. These have rings so adjusted that the whole series may be placed on one another in a pyramidal form.

It will be observed that some of these weights are in duplicate. The reason is this : the only figures used to denote the weights of the Metric System are 0, 1, 2, 5. But quantities must be weighed, which require also the figures 3, 4, 6, 7, 8, 9. To supply this want the weights marked with 2 are in duplicate. The result is that any quantity without exception, from 1 to 10, can be weighed by the following combinations :

$$1 + 2 = 3$$
$$2 + 2 = 4$$
$$5 + 1 = 6$$
$$5 + 2 = 7$$
$$5 + 2 + 1 = 8$$
$$5 + 2 + 2 = 9$$

The Synoptic Table shews near the bottom, on the right hand, the small weights used in pharmacy, chemistry, and similar delicate operations. These are twelve in number, laminar, and made of brass, silver, platinum, or aluminium. A cubic centimetre placed above shews that the water contained in it gives the gram, just as the water contained in the cubic decimetre gives the kilogram. It may be added that the water contained in the cubic metre gives the ton of the Metric System, so essential to the accurate calculation of the tonnage of ships, and so useful in innumerable mercantile and engineering operations.

Pound is given as the English name adapted to denote the half kilogram in a familiar way. It is originally a Latin

word, and is still co-extensive with the former bounds of the Roman Empire. But it has varied in its application within certain limits, so that there are now, or have been until lately, about 50 pounds in use. These have all a considerable similarity; but none of them is better entitled to be called a *pound* than the half kilogram; so near is its approach to the original Roman pound.

It is important to observe, that in countries where the Metric System is established by law, every measure and every weight has its name and value printed or stamped upon it. Accordingly, in the Synoptic Table, these marks are shewn in most of the figures, but are necessarily omitted in the smallest weights, and in some of the measures of capacity.

A circumstance well deserving of remark in this table is, that besides reading the whole of it from left to right, as we read the page of a book, it may also be read from top to bottom. This results from the constitution of the Metric System. If we proceed from the middle of the metre, which is drawn at the top, we descend directly to the cube of one of its decimetres, then to the same capacity in a cylindrical vessel of pewter, next to the same in a cylindrical wooden vessel, and then to the weight of water contained in these vessels, first in brass, and secondly in iron. The other vessels and weights are ranged on each side in perpendicular columns, and occupy the whole space with certain exceptions near the extremities.

It will not be supposed that this table exhibits before the eye the entire metric system. The delineation of the longest, largest, and heaviest measures and weights is necessarily omitted. But those which are introduced in their true size and form are quite sufficient to give a clear and correct illustration of the principles of the system, whilst the appended remarks and "Elements" will suffice to shew it in its most extended applications.

The table described in the preceding pages is in great part copied from the *Tableau Synoptique* of M. Daléchamps, published in Paris. This has been adopted for general use, not only in France, but very recently in Portugal.[1] It contains reduced representations of the larger measures and weights, which are noticed in the last paragraph; of the series of coins, which are a proper part of the Metric System; and of the thermometer, which is also decimal in its principles, being adjusted to the centigrade scale. These are omitted in the present table for the sake of brevity, uniformity, and simplicity; but they are highly deserving of attentive study, and may be recommended to all who have made themselves masters of the contents of the table in its condensed form. This table owes its neat, accurate, and compendious finish to the skill of Mr Charles Hutton Dowling, C.E., who, in addition to his complete theoretical knowledge of the subject, has had the most ample opportunities of observing and trying the practical application of the system.

It appears an auspicious circumstance, that the publication of this English table is undertaken by Messrs W. and A. K. Johnston of Edinburgh. It was in the northern capital of the British Islands that the Metric System first found an advocate, on this side the sea of separation. Whilst England was involved in war with France, the first exposition of the principles and grounds of the system was published under the title of *Base du Système Métrique* by the great mathematicians, Delambre and Méchain, who had been principally

---

[1] By permission of the Committee of Her Majesty's Privy Council on Education, a copy of the *Tableau Synoptique* of M. Daléchamps, and a copy of the Portuguese *fac-simile* of it by Don Fradesso da Silveira are exhibited in the South Kensington Museum, London. The Portuguese Synoptic Table is accompanied by a very fine series of the measures and weights of the Metric System beautifully arranged and displayed in a large mahogany case. This was presented by the Central Office for Measures and Weights at Lisbon, of which Don Fradesso da Silveira is the director. In the same part of the South Kensington Museum are shewn many other specimens illustrative of the Metric System, as well as of the Chinese, Swedish, Wurtemberg, and other systems.

concerned in measuring the arc, deriving from it the necessary conclusions, and determining all the arrangements for the construction of the system. Professor John Playfair then occupied the chair of Natural Philosophy in the University of Edinburgh. He had long devoted his attention to the great problems of the measurement of the earth, and the rectification of measures and weights, and as the successive publications which related to these subjects were issued under the authority either of England or of France, he wrote articles in the *Edinburgh Review*, which will always remain monuments, not only of his great eminence as a mathematician, but of his candour as a philosopher, and his admirable taste and elevated moral sense.[1] In discussing the Metric System, he takes into consideration its supposed defects as well as its excellences, but his inference from the whole is a decided approbation of the grand and generous attempt of its authors. He enunciates this opinion in the following paragraph, which is the conclusion of his most important essay on the subject, and which may also form an appropriate conclusion to the present description of the English Synoptic Table.

" We cannot finish our account of these scientific operations without expressing our wish that the uniformity of measures and weights were introduced into our own, and into every other civilised country. The difficulty is not so great as we are apt to think, when we consider the matter at a distance ; *and to effect it requires in reality nothing but for the Legislature to say, it shall be done.* As to the standard to be adopted, though we think the pendulum would have afforded the most convenient, yet when one has been actually fixed on and determined, that circumstance must greatly

[1] These articles may be found entire in Professor Playfair's collected works, published after his death in 4 vols, 8vo.

outweigh every other consideration. The system adopted by the French, if not absolutely the best, is so very near it, that the difference is of no account. In one point it is very unexceptionable. It involves nothing that savours of the peculiarities of any country, insomuch as the commissioners observe that, if all the history which we have been considering were forgotten, and the results of the operations only preserved, it would be impossible to tell with what nation this system had originated. The wisest measure, therefore, for the other nations of Europe is certainly to adopt the Metrical System. . . . It would not be necessary to adopt their names, which might not assort very well with the sounds that compose the language of other nations. But *the Metre*, by whatever name it may be called, *ought to be adopted as the unit of length*, and all the other measures of linear extension derived from it by decimal multiplication and division."

<div align="right">JAMES YATES.</div>

LAUDERDALE HOUSE, HIGHGATE, NEAR LONDON,
   24th February 1864.

<div align="center">

NEW EDITION OF

JOHNSTON'S COMMERICAL AND LIBRARY

CHART OF THE WORLD,

ON MERCATOR'S PROJECTION, 1864.

</div>

THIS well-known and valuable Work, of which many
thousand copies have been purchased by the principal
mercantile establishments of Europe, India, and the
Colonies, has, in accordance with the rapid progress of
geographical science, been thoroughly revised and corrected
up to the present year, 1864. It exhibits the most recent
changes in political boundaries; in Europe, the extent of
the new Kingdom of Italy, and the incorporation of Savoy
and Nice with France. In Asia, the encroachments of
Russia on the Chinese territory, in the basin of the Amur,
with the new Ports on the Pacific, the extension of British
Territory in India, and the new French Colony of Cochin-
China. In Africa, Speke's discovery of the Source of the
Nile, and the explorations of Barth, Baikie, and Livingstone,
in Central and Southern Africa. In America, the Colony of
British Columbia and Vancouver's Island, and all the new
Territories of the United States. In Australasia, the new
Colony of Queensland, Stewart's discoveries in the interior,
and the French Colony of New Caledonia.

<div align="center">

SIZE—6 FEET BY 4 FEET 8 INCHES.

</div>

PRICE—Coloured and Varnished, on a Mahogany Roller, or
in 4to Marocco Case, for Drawing-room or Library, £3, 3s.